

***Operable Unit 10-08  
Summary Report on the  
Subregional-scale  
Two-dimensional Aquifer  
Model***

October 2005

**Idaho  
Cleanup  
Project**

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# **Operable Unit 10-08 Summary Report on the Subregional-scale Two-dimensional Aquifer Model**

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## ABSTRACT

This document presents a two-dimensional conceptual model and two-dimensional numerical model representing groundwater flow in the Snake River Plain Aquifer in the subregional area surrounding and beneath the Idaho National Laboratory Site. These modeling activities make up the initial step in a phased project that will ultimately result in a three-dimensional flow and transport model that will form the basis of the record of decision for Waste Area Group 10, Operable Unit 10-08. The Operable Unit 10-08 modeling study will address a need for a model scaled to an appropriate subregional domain, so that risk to groundwater receptors can be calculated anywhere within the Idaho National Laboratory Site. Operable Unit 10-08 groundwater studies address areas outside the boundaries of the other individual waste area groups and consider the potential for risk created by commingling of residual plumes left by those groups. The modeling studies will also serve to communicate the cumulative risks for the aquifer from site activities to concerned stakeholders. In this role, the model will serve to integrate knowledge gained during investigations of individual waste area groups into a comprehensive aquifer management tool that will allow incorporation of smaller individual aquifer models in a seamless, consistent manner. The activities conducted for Operable Unit 10-08 groundwater modeling studies are guided by the negotiated and agency-approved *Idaho National Engineering and Environmental Laboratory Operable Unit 10-08 Sitewide Groundwater Model Work Plan*.

The conceptual sitewide groundwater model presented in this document has been developed from supporting evidence and interpretations derived from the disciplines of geology, geochemistry, earth heat flow, and hydrology. Using the conceptual sitewide groundwater model as a foundation, the two-dimensional subregional-scale aquifer flow model was developed. The simulation domain was refined from the original study area outlined in the groundwater model work plan. Model development included using three inverse calibration methods: (1) the traditional zonation method, (2) the pilot-point method, and (3) a coupled zonation/pilot-point method. The latter method was employed in an attempt to honor the large-scale geologic features identified in the sitewide groundwater model. The different calibration approaches were evaluated based on the agreement between simulated and observed heads, the reasonableness of the estimated hydraulic conductivity fields, and the uncertainty in the estimated hydraulic conductivity fields. The two approaches using the pilot-point method were also evaluated using particle tracking with starting points at site facilities. The simulated heads were greatly improved with either of the two approaches using the pilot-point method, but the coupled zonation/pilot-point method yielded the best agreement. The coupled zonation/pilot-point method, however, had much greater uncertainty associated with the resulting hydraulic conductivity field. The sensitivity of simulation results to two conceptualizations of aquifer thickness were tested, as was the influence of hydrologic properties, perimeter water influxes, and spatially variable surface recharge.

The two-dimensional modeling approach is recognized in this document to have limitations that will require simulation of contaminant transport in three dimensions. These limitations range from the obvious where contaminants are required to be uniformly mixed over the entire vertical profile in two-dimensional models to more complex issues related to preferential flow pathways identified in geochemical and isotope studies. Groundwater modeling that will honor these inferred preferential flow pathways will require the capability to vary aquifer properties in three dimensions.



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## ACRONYMS

AVH	Axial Volcanic High
B&R	Basin and Range
BLT	Big Lost Trough
BSU	Boise State University
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
CFA	Central Facilities Area
CFC	chlorofluorocarbon
cfs	cubic feet per second
DCE	dichloroethene
DEQ	Department of Environmental Quality
DOE-ID	U.S. Department of Energy Idaho Operations Office
EIS	environmental impact statement
EPA	U.S. Environmental Protection Agency
ESRP	eastern Snake River Plain
GMS	Groundwater Modeling System
INL	Idaho National Laboratory
INTEC	Idaho Nuclear Technology and Engineering Center
IWRRI	Idaho Water Resources Research Institute
MCL	maximum contaminant level
NWIS	National Water Information System
OU	operable unit
RI/FS	remedial investigation/feasibility study
ROD	record of decision
RTC	Reactor Technology Complex
RWMC	Radioactive Waste Management Complex

SRPA	Snake River Plain Aquifer
SWGM	sitewide groundwater model
TAN	Test Area North
TRA	Test Reactor Area
TSF	Technical Support Facility
USGS	United States Geological Survey
WAG	waste area group

# Operable Unit 10-08 Summary Report on the Subregional-scale Two-dimensional Aquifer Model

## 1. INTRODUCTION

The purpose of Waste Area Group (WAG) 10, Operable Unit (OU) 10-08, groundwater modeling studies is to provide a comprehensive evaluation of environmental impacts from operations at the Idaho National Laboratory (INL) Site to the underlying Snake River Plain Aquifer (SRPA). In particular, OU 10-08 groundwater studies address areas outside the boundaries of the other individual INL WAGs and consider the potential for risk created by the commingling of residual plumes left by those WAGs. The cumulative impacts on the SRPA are being evaluated during the OU 10-08 remedial investigation/feasibility study (RI/FS).

The OU 10-08 groundwater modeling studies are guided by the *Idaho National Engineering and Environmental Laboratory Operable Unit 10-08 Sitewide Groundwater Model Work Plan* (DOE-ID 2004). That plan was developed in collaboration with and review by the U.S. Department of Energy Idaho Operations Office (DOE-ID), the Idaho Department of Environmental Quality (DEQ), and the U.S. Environmental Protection Agency (EPA) to ensure that the products of the modeling studies match those needed for the OU 10-08 RI/FS process. This approach is intended to significantly expand the regulatory agencies' involvement in the development of the model by engaging them early and frequently over the course of the project. The overall modeling objectives statement and issues resulting from the collaborative planning effort are documented in the groundwater model work plan (DOE-ID 2004).

To enhance integration with the numerous parties involved in modeling aquifer flow and transport in the region, the project is using a tiered approach to the model design. This report presents the first step in our numerical simulations, i.e., a steady-state two-dimensional flow model. Development and testing of the two-dimensional model has helped us identify problems—for example, issues related to the flow field, localized versus regional issues of scale, and usability of certain well data—that will be resolved in the final three-dimensional model. Once approved for release by the regulatory agencies, the two-dimensional model will also be a means for opening communications with interested stakeholders, such as personnel from other WAGs, the United States Geological Survey (USGS), and state and federal agencies, on the scope and breadth of the OU 10-08 sitewide groundwater model (SWGM). The tiered approach is cost-effective and will help to identify technical and administrative areas of conflict early enough in the process to solve issues in a timely manner during the RI/FS.

As indicated, this model is the first step in a process that will eventually lead to comprehensive transport simulations for the INL Site that have an adequate technical basis. The first step is a two-dimensional flow model. Therefore, transport is not discussed in this document, nor is risk. Implications for transport are discussed in terms of simulated flow paths and possible commingling of anthropogenic contaminant plumes.

### 1.1 Background

A key component of the RI/FS effort (DOE-ID 2002) and long-term stewardship of the groundwater resources at the INL Site is the development of an INL sitewide groundwater-flow and contaminant-transport numerical model. The model will support decisions and be a tool for managing, compiling, and synthesizing data regarding the SRPA beneath the INL Site. Currently, several different aquifer models are used at the INL Site to satisfy specific program needs. These models are not consistent

in some cases and are sometimes redundant in the regimes they represent. Preparation of the SWGM provides the opportunity to promote consistency and eliminate redundancies in INL aquifer models. In the short term, the SWGM will be used to satisfy requirements for preparation of the OU 10-08 record of decision (ROD) and will supplement and support existing aquifer models. However, the design of the SWGM will eventually allow incorporation of smaller individual aquifer models in a seamless, consistent manner. Although vadose zone transport modeling is the responsibility of individual WAGs, the assumptions and implementation used in the individual WAG vadose zone models will be reviewed as the contaminant fluxes are implemented into the SWGM.

The need for the SWGM is also driven by advancements in the understanding of the INL Site subsurface and greatly improved computational capabilities. During the past decade, INL Site contractors, the USGS, and numerous academic institutions have obtained information that significantly changes the conceptual model of the subsurface beneath the eastern Snake River Plain (ESRP). In order to use these new data in determining the risk posed by contaminants from the INL Site, the data must be compiled and used to update conceptual and numerical models of flow and transport.

To the extent possible, the SWGM will be structured to integrate with and complement existing groundwater-flow and contaminant-transport models developed by individual WAGs and the USGS. This approach will enhance consistency across the INL Site and help resolve differences raised by different interpretations of subsurface data. Communication, staff integration, and data sharing are the foremost components in the strategy for integrating the SWGM with existing models. Meetings are held at regular intervals for technical and management staff involved with the active development or application of numerical simulations of the subsurface at the INL Site. Additionally, senior technical staff have been recruited from the major facility-scale groundwater projects to act as technical consultants on the design and construction of the SWGM. Additionally, use of the Environmental Data Warehouse to share and store data will ensure that the SWGM is developed and based on a common and consistent set of data.

The underlying strategy for the SWGM is a departure from the strategies for other models that have sought a single, unique solution to groundwater flow and transport. The SWGM strategy assumes that different and sometimes competing interpretations of groundwater flow and transport will develop because of the relatively sparse subsurface data set for the complicated INL Site subsurface and the many programs utilizing these data for varied purposes. Consensus on a single conceptual model will be difficult to achieve and will evolve as more data become available. The SWGM strategy for integration includes the capability to test interpretations generated by various projects (solving specific problems). Cross comparison between interpretations will define the bounds of flow and transport in the SRPA at the scale of the INL Site. Thus, unique solutions derived by individual projects can be included in the SWGM as long as the solutions are consistent within a range that is reasonable for possible interpretations described by the subregional understanding of aquifer flow and transport.

### **1.1.1 Regulatory Background**

The WAG 10 OU 10-08 RI/FS work plan (DOE-ID 2002) describes the enforceable milestone schedule for OU 10-08, and the reader is referred to that plan for a detailed summary of the events controlling the final deliverable date for the OU 10-08 ROD. The 10-08 ROD is expected to be the last major ROD completed at the INL Site, and the deliverable date depends on when the other WAG RODs are signed.

Currently, two other major RODs remain to be finished. The planned completion date for the OU 3-14 draft ROD is December 31, 2006, and the planned completion date for the draft OU 7-13/14 ROD is December 31, 2007. When the OU 7-13/14 ROD is signed (assumed to be 6 months later), the period for completing the OU 10-08 RI/FS begins. The draft OU 10-08 RI/FS report will be due to the

regulatory agencies for review within 15 months, and the draft OU 10-08 ROD will be due two years after the OU 7-13/14 ROD is signed. Assuming the OU 7-13/14 ROD is signed in June 2008, the draft OU 10-08 RI/FS report will be due September 2009 and the draft OU 10-08 ROD will be due June 2010. The current working schedule for the OU 10-08 RI/FS, which this groundwater modeling effort supports, will produce the RI/FS report in September 2009. Obviously, this schedule is subject to change. The phased approach for developing the OU 10-08 SWGM has the advantage of providing schedule flexibility to ramp up or down project activities to meet a moving deliverable date.

The schedule of the groundwater modeling project will also tie to and support the aquifer flow and transport models of the OU 3-13 and OU 7-13/14 RODs. It is critical that the OU 10-08 RI/FS activities overlap and are consistent with remedial decisions across the INL Site, because all WAGs will eventually be managed under WAG 10 as activities are completed at other WAGs. The schedule overlap with the other WAG groundwater models will ensure a smooth and cost-effective transfer to the long-term stewardship role of WAG 10. A final important need addressed under the current OU 10-08 RI/FS schedule is the ability for managers to consolidate all groundwater concerns into a single internally consistent representation of the aquifer beneath the INL Site for communication to concerned stakeholders. The importance of the OU 10-08 SWGM is demonstrated by two important facts: (1) the SRPA, a sole source aquifer, is the number one INL-related concern for the population of eastern Idaho, and (2) predicted contaminant levels in the SRPA drive the selection of most remedies for individual WAGs. For the aforementioned reasons, INL Site management team (including the agencies) has taken a proactive, technically robust approach for developing the SWGM.

### **1.1.2 Previous Modeling Studies**

Numerical modeling of groundwater flow beneath the INL Site has been ongoing for many years, both at the INL sitewide scale and for much larger areas of interest. Numerical models for INL groundwater problems were utilized as early as the mid-1970s (Robertson 1974). The USGS Regional Aquifer-System Analysis Program produced several SRPA models at various scales for use as characterization tools dealing with regional water-resource issues. Recent numerical models have included the State of Idaho Regional Water Resource Model and the USGS Subregional Model. At the INL Site, remedial investigations mandated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) have resulted in several flow and transport models; these include three numerical flow and transport models currently in preparation for WAGs 1, 3, and 7.

Historical modeling efforts are important, because they identify documented successes that can be incorporated into the SWGM and because they help to identify issues and problems that can be avoided. Several historical models provide input to the WAG 10 conceptual model and provide useful summaries of data to be used in the SWGM. The following subsections summarize basic features and applicable results for several regional ESRP and subregional INL Site models and three active individual WAG aquifer models.

**1.1.2.1 Numerical Modeling Studies from 1974 to 1990.** In one of the first comprehensive subregional numerical transport-modeling studies, Robertson (1974) calibrated a two-dimensional flow and transport model with data from the early 1940s through 1972 and used the calibrated model to predict solute transport to the year 2000. Solutions were obtained using the method of characteristics. The model assumed a constant aquifer thickness of 76 m (250 ft) and included both steady-state and transient-flow conditions. The minimum grid dimension was 1,275 m (4,183 ft) on a variable grid oriented to the interpreted principal direction of regional groundwater flow. The grid consisted of 39 rows of cells along the principal axis of flow (southwest) and 36 columns of cells along the axis perpendicular to flow (southeast). Robertson's model domain represented an area of 6,599 km<sup>2</sup> (2,548 mi<sup>2</sup>) shown in Figure 1-1.

Robertson's transport model was used to predict concentrations in groundwater of tritium, chloride, and Sr-90 emanating from the Reactor Technology Complex (RTC) (formerly known as the Test Reactor Area [TRA]) and the Idaho Nuclear Technology and Engineering Center (INTEC). An important result of the work came from matching predicted chloride concentrations to observed chloride concentrations using an unexpectedly large ratio (1.5) of transverse (137 m [449 ft]) to longitudinal dispersivity (91 m [298 ft]). The model was first reworked by Lewis and Goldstein (1982) to evaluate this large ratio. Their analysis resulted in a list of problems with the original model, including a grid that was too coarse to produce an accurate simulation of contaminant plumes. Goode and Konikow (1990a) revisited the model a second time in an attempt to explain the transverse-to-longitudinal dispersivity ratio using transient recharge from the Big Lost River. Their results were inconclusive.

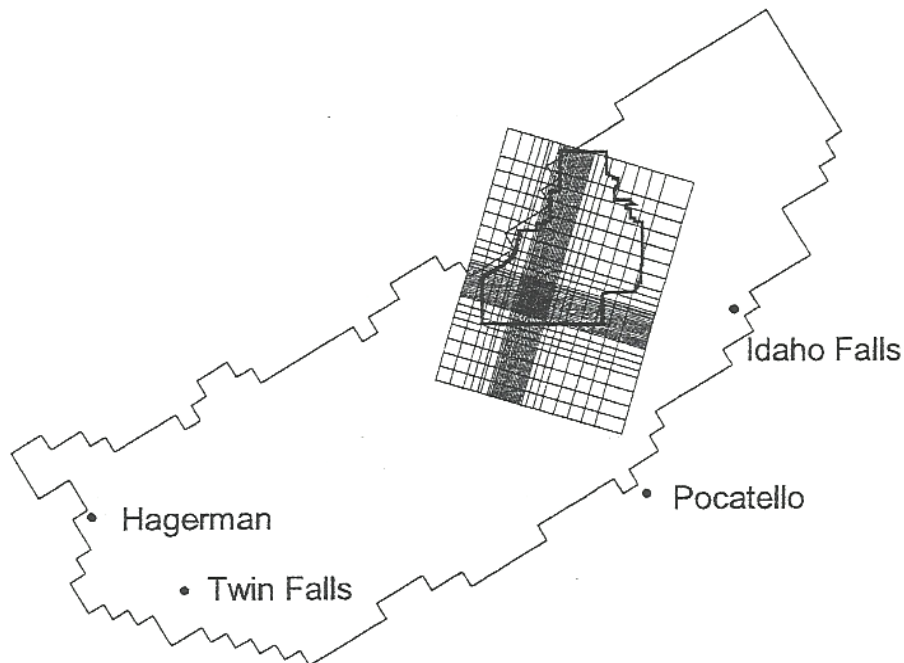


Figure 1-1. Domain and grid configuration of early flow and transport model (Robertson 1974).

**1.1.2.2 Spent Nuclear Fuel Environmental Impact Statement Model (1990).** A two-dimensional, steady-state flow and transport model was developed (Arnett and Springer 1993) for the INL Spent Nuclear Fuel Program's environmental impact statement (EIS). The flow model simulated an area larger than the INL Site in order to utilize natural boundary conditions. The 1990 EIS model domain was similar to Robertson's model, as shown in Figure 1-2. The northern and southern boundaries were chosen far from the contaminant transport area of interest to minimize their effects on the solutions. These boundaries were modeled with constant heads interpolated from regional head maps. Recharge and discharge from INL Site ponds and wells were neglected.

This EIS modeling effort assumed two-dimensional, horizontal-flow, and steady-state conditions in a heterogeneous, isotropic, confined aquifer. A structured, variable grid size was used with refinement in the transport areas of interest, which consisted of INTEC, the Naval Reactors Facility, the Radioactive Waste Management Complex (RWMC), Test Area North (TAN), and the RTC. The grid axes were rotated clockwise from true north to match the regional flow direction. The model was developed using MAGNUM-3D, a finite-element code designed to model two- or three-dimensional transient or steady-state groundwater flow.

The EIS transport model was constructed as a subarea of the flow model domain in the vicinity of INTEC, the RTC, and the RWMC and corresponding to the refined area of the flow model. The transport model simulated tritium, Sr-90, and I-129 plumes beneath the RTC and INTEC. Transport was simulated using CHAINT, which is a two-dimensional, finite-element solute transport code. Tritium data from 1985 were used to calibrate transmissivity and effective porosity; Sr-90 and I-129 plume data were used to calibrate the strontium and iodine retardation.

However, the EIS model was unable to satisfactorily simulate the observed plume configuration. The assumption of two-dimensional flow was considered reasonable for the regional-scale groundwater flow, but it was believed that a transient flow simulation would be required with this model to better simulate the highly dispersed observed contaminant plumes. As a result, this model significantly overpredicted I-129 concentrations in the SRPA downgradient of INTEC, as demonstrated by subsequent groundwater monitoring results for the period 1990 to 2005.

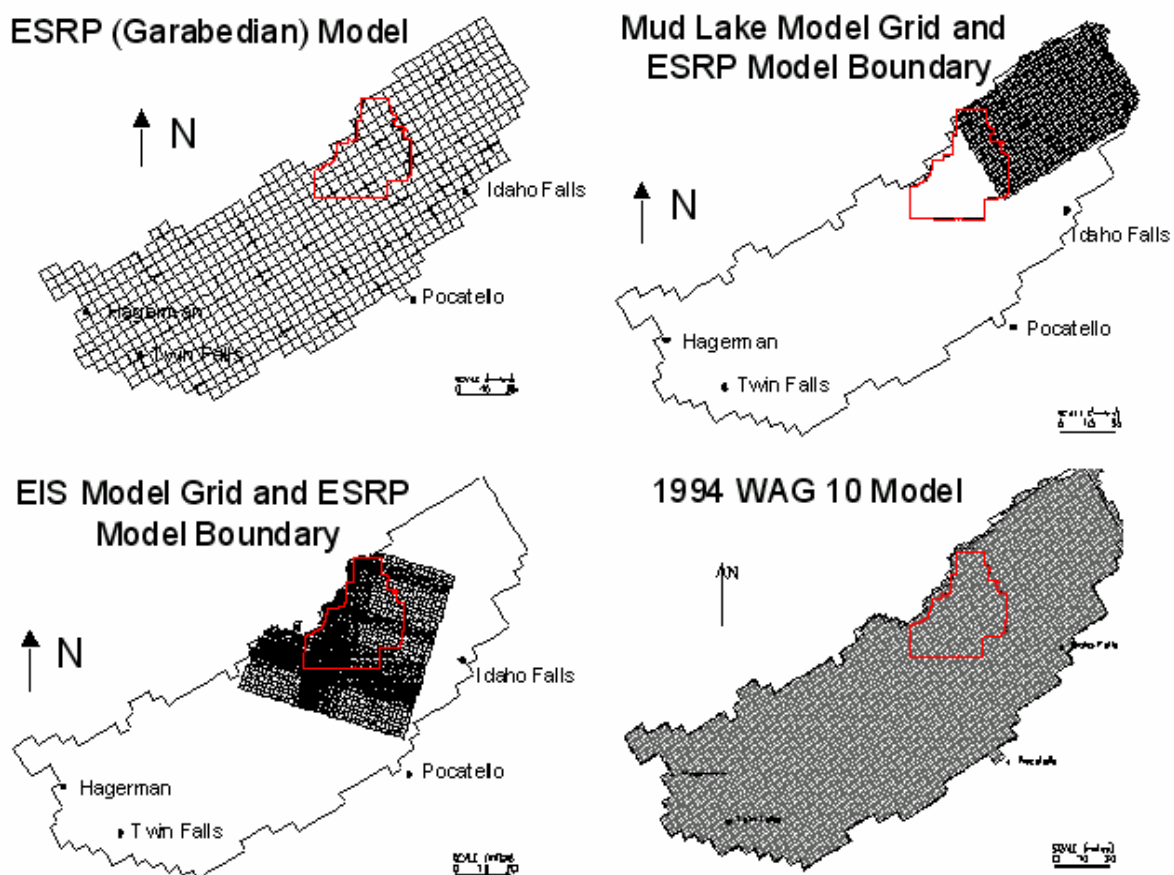


Figure 1-2. Domain and horizontal grids of four early regional and subregional models.

**1.1.2.3 USGS ESRP Water Resource Model (Garabedian 1992).** A numerical flow model of groundwater underlying the entire ESRP was prepared by Garabedian (1992) as part of the USGS regional aquifer systems analysis for management of the groundwater supply. This model did not include contaminant transport. The four-layer model was prepared using MODFLOW. Vertical variations in head within each model layer were assumed to be negligible, and head losses between layers were assumed to be controlled by confining beds near the base of each layer. This layered modeling approach is referred to a quasi-three-dimensional or multi-aquifer approach and is not fully three-dimensional. The ESRP Garabedian model grid consisted of uniformly dimensioned cells that were 6.4 km (4 mi) on a side

(Figure 1-2). The model layers varied in thickness. Grid axes were also rotated for better alignment with the principal direction of regional groundwater flow.

The Garabedian ESRP steady-state model was calibrated by the zonation approach using hydraulic conductivities and river conductances within reasonable ranges. Isotropic conditions were assumed for horizontal movement. The initial conditions for the transient model were derived from a pre-irrigation steady state, and the model simulated water-level changes from 1891 to 1980 by adding recharge from irrigation. The model is most useful for summarizing regional data and providing estimates of regional hydraulic properties. Although there are issues with this model regarding several features, including tributary valley average annual underflow rates near the INL Site and transmissivity values near the INL Site, the understanding of the overall regional flow system gained by development and application of the ESRP model provides helpful background information for the SWGM.

**1.1.2.4 USGS Mud Lake Water Resource Model (Spinazola 1994).** The USGS constructed a numerical groundwater flow model using MODFLOW to evaluate changing water-management practices in the Mud Lake area (Spinazola 1994). This model was a subregional five-layer model consisting of a uniformly sized grid of 40 rows and 64 columns, with each cell 1.6 km (1 mi) on a side, aligned similar to the ESRP model (rotated approximately 31° counterclockwise). The Mud Lake model domain, representing 5,698 km<sup>2</sup> (2,200 mi<sup>2</sup>), is shown in Figure 1-2. Layers represented sub-unit thicknesses ranging from 30 m (100 ft) at the top of the aquifer to almost 305 m (1,000 ft) at its base.

Head-dependent flux boundary conditions were used for the southwest boundary and a portion of the southeastern boundary of the Mud Lake model. No-flow boundary conditions were used for parts of the northwestern boundary that abut mountain ranges and for parts of the southeastern boundary. Specified-flux conditions were used for portions of the northwestern boundary corresponding to tributary underflow and to simulate recharge from precipitation and withdrawals for pumping and irrigation.

The steady-state Mud Lake model was calibrated to 1980 conditions using the trial-and-error approach with multiple conductivity zones per layer. Some transient conditions were also calibrated. Evaluation criteria included configuration of measured and simulated water tables—in particular, the shape and position of specific contours. Significant discrepancies resulted between measured and simulated water levels. These discrepancies were from apparent cumulative effects of uncertainty in several components of recharge and discharge.

**1.1.2.5 WAG 10 Regional Flow Model (1994).** In 1994, a regional flow model was developed using MODFLOW to support WAG 10 objectives. These objectives included modeling future transport and defining regional flow at individual WAG scales. This model's domain covered the entire SRPA and was the same as the USGS ESRP model. Similar four-layer, quasi-three-dimensional approach and boundary conditions were used as well as similar recharge/discharge estimates. The USGS model discretization was subdivided from 6.4 km (4 mi) per grid side to 1.6 km (1 mi) per grid side (Figure 1-2) to provide better resolution for individual WAGs.

The 1994 WAG 10 model combined hydraulic conductivity zones from the USGS ESRP, Mud Lake, and EIS models. This combination allowed greater detail in the area immediately upgradient of the INL Site. The model successfully integrated INL Site and ESRP scales with regard to groundwater flow. Steady-state and transient conditions were used to calibrate hydraulic head, gradient, and overall water budget. The model was calibrated only to targets within the INL Site boundary and only within the top layer of the model. Hydraulic gradient targets were satisfied at intermediate scales but not local scales. The larger scale of the model limited the accuracy of the hydraulic gradient and flow directions for defining the regional setting of the local scale. The 1.6-km (1-mi) grid size proved too coarse to define boundary conditions at individual WAG scales.

### 1.1.3 Current Modeling Efforts

The following subsections describe several modeling efforts that are currently under way to define regional and subregional groundwater flow and transport in the SRPA and in the vicinity of the INL Site. The Idaho Water Resources Research Institute (IWRRI) at the University of Idaho is preparing a new water resources model. The USGS is developing new subregional flow and transport models. In addition, three WAG-specific groundwater models that are of interest to the WAG 10 groundwater modeling team have been developed.

**1.1.3.1 State of Idaho Regional Water Resource Model.** The State of Idaho has developed groundwater models to support water resource management and adjudication of groundwater and surface water rights on the ESRP. Recently, the IWRRI's Eastern Snake River Plain Aquifer Model Enhancement Program completed a refined regional SRPA flow model (Wylie 2003). The purpose of the effort is to better detail the extent and thickness of the aquifer domain by using grid refinement in areas of intensive groundwater use and groundwater/surface water interaction, particularly along the eastern and southeastern margins of the plain, and to improve the understanding of water table dynamics over the past 20 years.

The two-dimensional model consists of a single layer with variable thickness. The model grid consists of 104 rows and 209 columns of uniformly sized cells with dimensions of 1.6 km (1 mi) on a side. Grid axes are aligned with the principal direction of regional flow (rotated 31.4° counterclockwise). The model domain is shown in Figure 1-3 relative to INL Site boundaries. In the IWRRI model, the aquifer is treated as a confined system. The central focus of the model is on the interaction of the groundwater flow system with the Snake River and on seasonally varying inputs from tributary valley underflow.

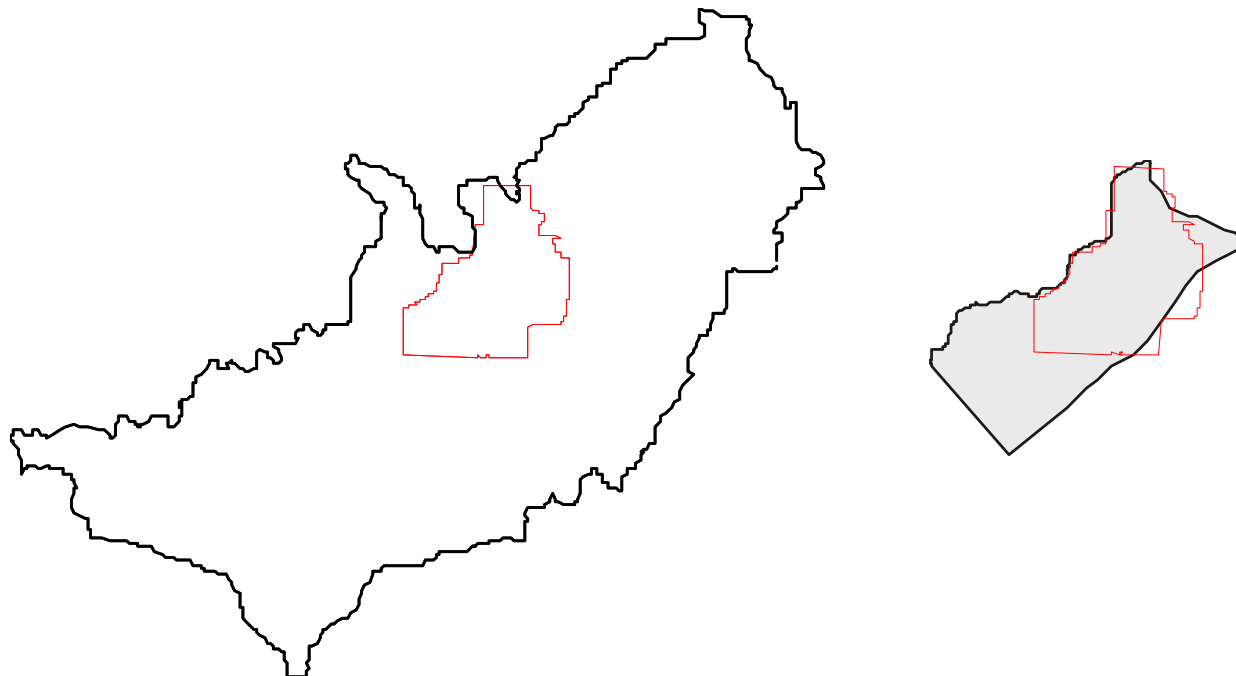


Figure 1-3. Model domain extent for two contemporary modeling efforts (State of Idaho Regional Water Resource model, left; USGS, right).

**1.1.3.2 USGS Subregional Model.** The USGS is currently developing a conceptual model that will support preparation of next-generation flow and transport models for a subregional domain surrounding the INL Site.<sup>a</sup> The features of the USGS conceptual model include multiple layers, variable aquifer thickness, and three major hydrogeologic units.

The current USGS conceptual model encompasses an area of 5,025 km<sup>2</sup> (1,940 mi<sup>2</sup>), including most of the INL Site, and extends 121 km (75 mi) from northeast to southwest and 56 km (35 mi) from northwest to southeast (Figure 1-3). The aquifer is treated as an equivalent porous medium with nonuniform properties. Three major hydrogeologic units represent the hundreds of known individual basalt flows and sedimentary interbeds. These include younger, fractured basalts and permeable sediments; younger, dense-basalt, and less-permeable sediments; and older, much-less-permeable, altered basalts and interbedded sediments.

The conceptual model developed as part of the current USGS modeling study differs from conceptual model elements of the proposed SWGM. These differences include the estimates of maximum thickness of the effective aquifer, areal distribution of thickness, and downward flow and deep circulation of contaminants. The USGS model uses an assumed base of the aquifer delineated primarily from electrical resistivity soundings. These soundings indicate that the aquifer base ranges from 213 to 1,463 m (700 to 4,800 ft) below land surface. This results in an active aquifer thickness of over 1,067 m (3,500 ft) in some areas of the domain. This maximum thickness is significantly larger than that of the current OU 10-08 conceptual model. Additionally, the distribution of aquifer thickness differs from OU 10-08 thickness distributions, although the USGS thickness distribution generally trends from thinner in the north to thickest just south of the INL Site boundary.

Boundary conditions include a no-flow boundary to the southeast that corresponds to a groundwater flow path, as determined from the Garabedian (1992) model. Constant-flux boundaries are used to the northeast and southwest. Specified-flux boundaries are used along the northwest boundary to represent tributary underflow. Some downward groundwater flow is being included in areas of known vertical gradient, especially where the less-permeable, massive basalts apparently intersect the water table south of the INL Site. This implication of downward flow and deeper circulation of contaminants that migrate offsite is a third conceptual model difference from the OU 10-08 conceptual model.

**1.1.3.3 INL Individual WAG Models.** Numerical groundwater flow and contaminant transport models are in use for WAGs 1, 3, and 7. The models for WAGs 3 and 7 were developed to be coupled with vadose zone models. The WAG 1 model was developed for CERCLA risk assessment of the SRPA without vadose zone modeling. These three models are based on different numerical solution codes, grid dimensions, and contaminants of concern (Table 1-1).

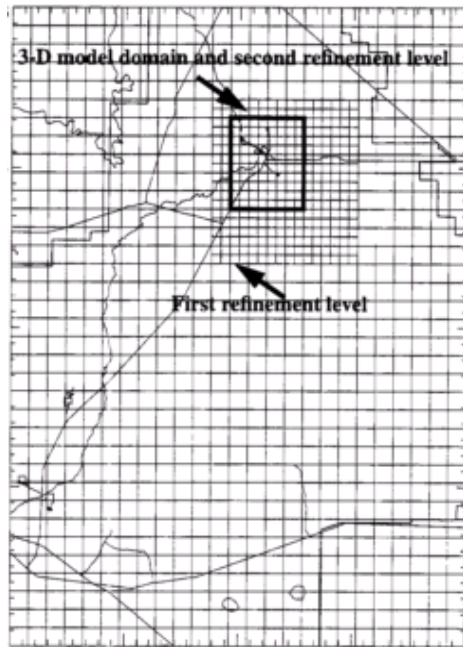
**WAG 1**—The WAG 1 model consists of a saturated-only domain with a point source representing direct injection of waste to the aquifer via the TAN disposal well (Technical Support Facility [TSF]-05) and gradual release from a secondary source (sludges in the SRPA around the disposal well). The model contained a 1,600-m (5,249-ft) base grid dimension but was refined over six levels down to an 25 m (82 ft) grid dimension within the source area (disposal well). The model includes a far-field domain (the portion of the INL Site from TAN to the southern INL Site boundary). The model is a multi-layered, fully three-dimensional model bottomed by the QR interbed, which provided an effective base of the trichloroethene contamination zone. The model was initially developed using TETRAD but was later converted to MODFLOW using a smaller domain. An effective porosity of 0.03 was required to match tritium breakthrough observed in monitoring wells. The model domain is shown in plan view in Figure 1-4.

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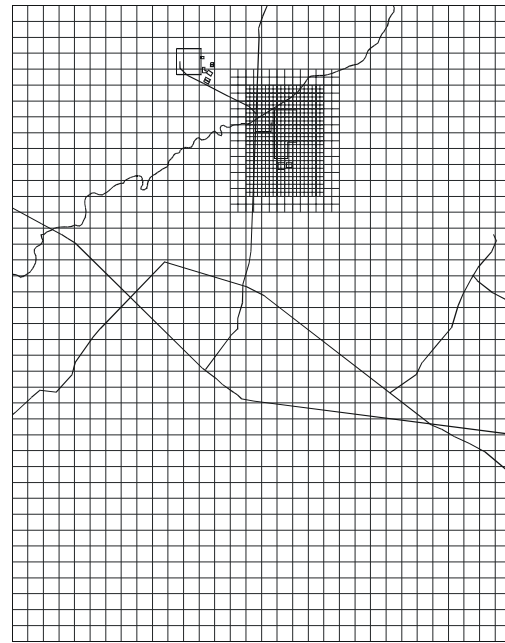
a. Ackerman, D. J., S. R. Anderson, L. C. Davis, B. R. Orr, G. W. Rattray, and J. P. Rousseau, 2001, *A Conceptual Model of Flow in the Snake River Plain Aquifer at and near the Idaho National Engineering and Environmental Laboratory with Implications for Contaminant Transport*, U.S. Geological Survey Draft Report.

Table 1-1. Summary of numerical modeling activities for WAGs 1, 3, and 7.

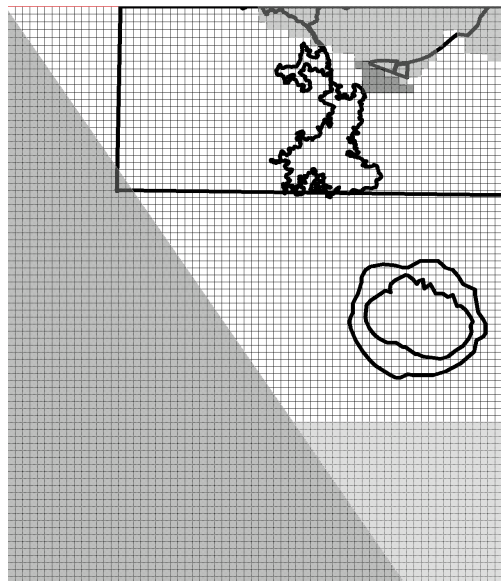
WAG	Model Code	Grid Dimensions	Contaminants of Concern
WAG 1 (TAN)	TETRAD, converted to MODFLOW, no vadose zone model	5,249 ft (82 ft refined)	Trichloroethene
WAG 3 (INTEC)	TETRAD, coupled with a TETRAD vadose zone model	1,312 ft (656 ft refined)	Sr-90, Tc-99
WAG 7 (RWMC)	TETRAD, coupled with a TETRAD vadose zone model	1,000 ft (500 ft refined)	Carbon tetrachloride



a) WAG 1 groundwater model



b) WAG 3 groundwater model



c) WAG 7 groundwater model

Figure 1-4. Model domain and grid layout for three individual WAG models.

**WAG 7**—The saturated groundwater model developed for WAG 7 is coupled to the WAG 7 vadose zone model. Both models use the TETRAD numerical code. The saturated model consists of a three-dimensional, seven-layer system employing five constant conductivity media types. The horizontal grid dimensions are 305 m (1,000 ft) per side, with grid refinement in the vicinity of the RWMC's Subsurface Disposal Area to 152 m (500 ft) per grid side (Figure 1-4). The model domain was recently extended to the southwest and now extends several kilometers south of the INL Site boundary. After this modification, the domain extends 21 km (12.9 mi) from east to west and 25 km (15.3 mi) from north to south. The flow model was calibrated to fall 2003 water-level data. Relative to the original domain, the fit between observed and simulated heads with the extended domain was poorer; this prompted discussion on the need for a new WAG 10 sitewide groundwater model to support individual WAG models.

## **1.2 Document Scope**

This document addresses the conceptual SWGM and includes the supporting evidence and interpretations upon which the SWGM is based. The disciplines of geology, geochemistry, geothermal systems analysis, and hydrology are included in the development of the SWGM. Using the results of the SWGM, a two-dimensional sub-regional scale aquifer flow model is calibrated using three different inverse methods. The calibration results and uncertainty in estimated hydraulic conductivity are compared between the methods. Sensitivity to boundary conditions and estimated hydraulic properties are evaluated.

## **1.3 Document Overview**

This document contains two primary parts. First, the conceptual model of the movement of water and the basis for the conceptual model are described. Second, the development of a two-dimensional flow model based on this conceptual model is described. The flow model includes different conceptualizations to test the effect of uncertainty in some aspects of the conceptual model.